Lateral boron distribution in polycrystalline SiC source for growth of fluorescent 6H-SiC

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Today most white LEDs are phosphor based, where blue light from a GaN-LED is partly converted by a phosphor layer to other colors, combined and as a result white light will be emitted. However, the efficiency, the long term stability and the color rendering index are far from perfect. To further improve white LEDs, it has been recognized that the phosphor can be replaced by fluorescent 6H-SiC. The yellow donor-acceptor pair luminescence of 6H-SiC co-doped with nitrogen and boron can be utilized as a converter material in an LED device [1]. Thick 6H-SiC layers are needed and the Fast Sublimation Growth Process (FSGP) is preferable [2]. In FSGP, the source material should include the dopants. This kind of source material has to be produced by custom made sublimation processes or by sintering techniques. In both cases, the source material is a key issue for high brightness of the fluorescent 6H-SiC layer since it contains the dopants and is a growth rate determining step.

In this work we have investigated boron distribution in two types of polycrystalline sources used for growth of fluorescent layers. The poly-SiC is co-doped with nitrogen and boron concentration of $1x10^{18}$ cm^{-3} and $1x10^{19}$ cm^{-3}, respectively. The poly-SiC seed has been prepared by sublimation in a PVT (physical vapour transport) set up. In addition to PVT material, a sintered B/SiC source has been employed.

Secondary ion mass spectrometry (SIMS) has been utilized to obtain boron concentration versus depth profiles as well as lateral distributions (ion images). Ocular inspection of color, which was compared with Raman identification of the polytypes, has been employed to identify the polytype of different grains.

In Fig. 1, SIMS images of the lateral ^{11}B and ^{12}C distribution are displayed for a PVT poly-SiC sample and a sintered SiC sample. Higher concentration is seen as brighter regions in the SIMS images. In the poly-SiC material, the ^{11}B distribution (Fig.1a) shows a pronounced concentration variation compared between grains while the ^{12}C (Fig.1b) and the Si (not shown) signal stay constant. A higher boron concentration is revealed in the 6H-SiC (up to the right) compared to the 4H-SiC region (lower left corner). The boron concentration within a grain is constant. No enhanced boron concentration is revealed at the grain boundaries. Our results indicates that no B inter-diffusion between grains are present at 2200 °C during the

PVT growth or after the FSGP use at 1900 °C. However, it has been shown that boron diffusivity could be high at the used temperature in single crystal material if the experimental conditions are different [3-5]. In the sintered SiC sample, regions with higher ^{11}B concentration (Fig.1c) correlate with a lower ^{12}C (Fig.1d) and Si (not shown) content. In Fig. c and d, two regions are indicated by circles, one with high and one with low boron concentration, to facilitate a comparison between signals. These results indicate that boron remains between the SiC grains after sintering, and such boron could influence the epitaxial growth.

Our results will be further discussed from the kinetic point of view. We will show that there is an influence on the luminescence from the two types of source materials.

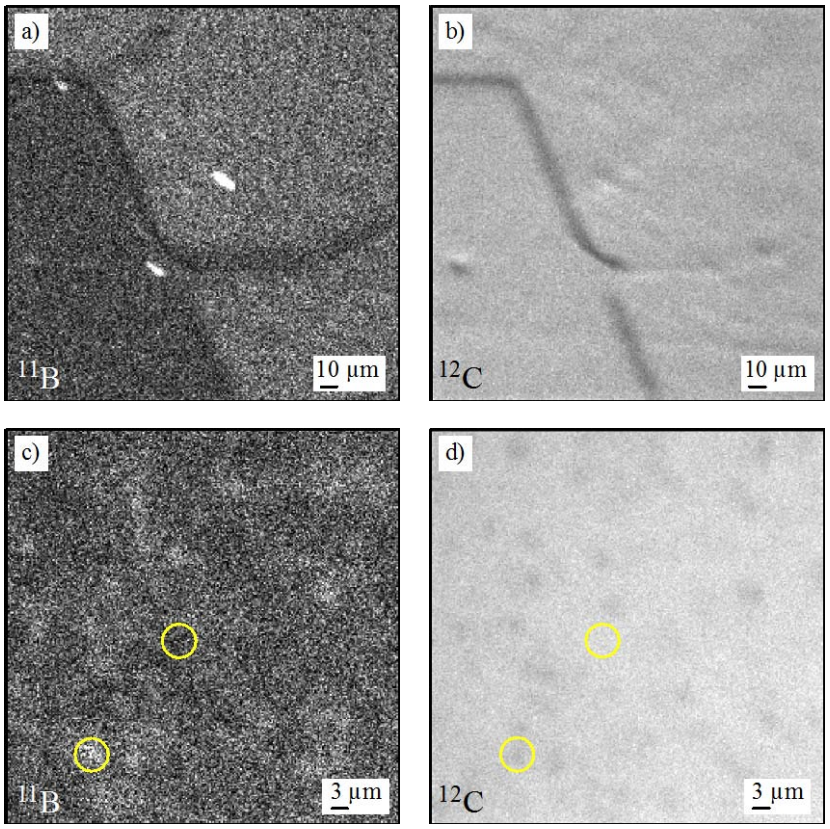

Fig.1. Ion images of ^{11}B and ^{12}C distribution in poly-SiC (a and b) and sintered SiC (c and d) obtained by SIMS. Higher concentration is seen as brighter regions The boron doping level is ~$1x10^{18}$ cm^{-3}. A linear concentration scale is used. Yellow circles are included in c) and d) as guides for the eyes.

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